

below the normal. The pressure in North America was therefore directly in the opposite sense to that in Siberia. Considering next the second period of low pressure in Siberia, viz:

February 5 to 20, 1915.—A month of unusually low pressure in central and northeast Siberia; while nine anticyclones were charted in Canada, it is said of them that they were not as energetic as is often the case in the winter season and their accompanying cold waves also lacked intensity, the result being a mean temperature in Canada very much above the average. During this month low pressure had overspread northwest Canada and the United States west of the Rockies, and the temperature everywhere in the latter except in Arizona and western New Mexico was considerably above the normal. Precipitation was abundant on the Pacific coast, the Missouri Valley, and the upper Mississippi Valley. The inference from the foregoing seems to be that the low pressure in Siberia had spread eastward across the Pacific into Alaska and over the western part of the continent as far south as Mexico. On the eastern seaboard, however, the opposite pressure conditions prevailed.

Consider now the three cases of high pressure in Siberia. I remark first that the time intervals of these, viz, November 1 to 27, January 3 to February 4, and February 21 to March 3 do not except in the two cases first mentioned lend themselves to direct comparison with calendar month means.

November 1 to 27, 1914. A month of high pressure in Siberia.—Pressure in Canada and the United States was not far from normal with a tendency toward high pressure in the western part of the continent, except that low pressure was the rule in Alaska and northwest Canada. Nine anticyclones were charted in Canada and 13 in the United States, 5 of the latter coming from Canada. In general they were lacking in intensity and, partly due to

that fact and partly to the movement of a large number of cyclones eastward along the border between Canada and the United States, the month as a whole was warm from the Atlantic to the Pacific and as a rule dry.

January, 1915: High pressure in Siberia.—Pressure was half an inch below the average at Dawson, Yukon Territory, and a less amount generally throughout northwest Canada; while 10 anticyclones were charted in that country they were not of the energetic type often prevailing in January. Fourteen cyclones were charted, half of which first appeared on the Alaskan coast or in other words along the eastern margin of the winter anticyclone of Siberia. In United States pressure was low in many parts of the country, the greatest departures being in the lower Missouri Valley, Kansas, northern California and western Oregon, and western Washington. Thirteen anticyclones were charted, eight of which came from Canada and four from the Pacific. The temperature was close to normal in all parts of the country and precipitation was fairly abundant in the majority of districts.

It must be confessed that the pressure level in the region usually occupied by the great winter anticyclone of Siberia does not appear directly to greatly modify or influence the weather in North America either currently or subsequently. Indirectly, however, it may enter as a causative influence, thus when pressure is much above its normal level in Siberia low pressure is likely to be the rule on its eastern margin which in turn makes for mild winter temperature and diminished precipitation in North America; on the other hand when pressure is much depressed in northeast Siberia, the probabilities are that pressure over Alaska and northwest Canada will be high and thus create low temperature and moderate precipitation in North America. The evidence is however incomplete and inconclusive.

NOTES ON LINE SQUALLS

551.515

By C. G. ANDRUS

[Weather Bureau, New York, N. Y.]

Line squalls have earned for themselves a reputation of severity and malevolence which has made airman deal with them with respect and caution. Fatalities and crashes, frequently with open gun, have been traced to line squalls as the direct or contributory cause in a large number of wrecks attributed to weather. Unlike fog, which is more or less quiet it is an active, moving, and transient expression of meteorological violence and it may generally be observed before its onset and occasionally anticipated with great accuracy. Half the battle so far as the airman is concerned is to be prepared for it; to do this it should be recognized both by its indicative characteristics on the weather map and its actual appearance in the air.

To spot the conditions favorable to line squalls on the weather map it requires that we divide the depressions or "lows," and even the troughs between highs into warm and cold sides. The warm side indicated by southerly winds (SE. to SW.) is found on the lower part of the front of the low; behind the low are NW. winds (W. to N.) and comparatively cold air. Occasionally the question arises quite honestly "what occurs where they meet?" They do not meet in the sense of colliding in an impact, but the cold air by virtue of its heavier weight wedges under the warm breezes from the south which are quite ready to rise as a result of their lighter weight. Where this undercutting cold "front" curls up before it the lighter and

usually moist warm air, a long line of squalls and low-arching clouds are now formed as sufficient chilling by both contact and raising condenses the water vapor into rolling clouds, which frequently reach well above the ceiling of ordinary airplanes. The lifting action is rather violent and sudden and the resulting condensation into clouds is abrupt and intense, so that the phenomena associated by experienced airmen with such condensation are frequently found highly developed. The thunderstorm, sleet, severe snow, and extraordinary instability and bumpiness may all be present within the squall which is itself moving forward usually at about 15 to 30 miles per hour toward some easterly direction.

Once detected, their line of march may be timed quite accurately, although it is not equally easy to predetermine their violence which is variable and capricious. The "northers" of the Plains States are line squalls and are sometimes entirely of wind, the moisture supply on both sides of the depression being too scanty even for clouds. Nearer the Lake region and along the Gulf and Atlantic coasts they tend to be "wet" as well as windy. Unfortunately adding moisture to the problem tokens more violence produced by heat liberated by the condensation, as well as nullifies visibility and even ceiling for the airmen. Safety lies in getting through the squall cloud as rapidly as possible, at the same time maintaining a sharp lookout for any brightening areas ahead. All this must

be done at a fair altitude, 4,000 or more feet above the ground so that the violent vertical currents will not dash the plane to the ground. Ice and sleet add to the hazards which dictate altitude as desirable. There seems to be little choice as to which is safer, coming up on the lines squall from its rear or its front; it is undeniably easier to detect it and prepare for it when the plane is running to meet it because its front is more defined than the more trailing characteristics of its rear.

It is noteworthy that many difficulties and crashes caused by line-squall phenomena have occurred in the dark hours, which leads to the conclusion that they were mistaken for large thunder and rain storms in the darkness, whereas their "line" features would have been at once recognized and properly met in daylight. This suggests some careful scrutiny of the weather map as a real aid, with the rule in mind that wherever there appears a marked line along which conflicting winds with strongly contrasted temperatures there, one will find line-squall developments if the line runs southward or southwestward from the central portion of the low. British meteorologists have studied line squalls with a thoroughness born of danger; their practice of giving the squall its victims' names is perhaps not particularly unctuous, but at least compelling of attention and the dramatic possibilities of the details of the *Eurydice* squall where would be portrayed the last moments of a great training ship caught unawares by a line squall might indelibly point a moral of value.

In the air these squalls have taken tolls of life and property in the heavier-than-air ships and we recall the line squall which swept eastward between Chicago and Toledo on the evening of November 29, 1927. It passed just east of Chicago at 7 p. m. and 12 hours later the weather map clearly delineates it near Cleveland. About 10 p. m. in the eastbound mail plane, pilot Axberg crashed into the ground near Goshen, Ind., in the midst of a violent squall. Undoubtedly it was the line squall, met in the darkness by the pilot, who overtook it from the rear, perhaps unaware that the gathering obscurity culminated ahead of him in a climax of violent snow, great air bumps, and annihilated vision. The line of squalls passed there at that time and even on the ground was of great although passing violence.

Of similar nature and likewise a manifestation of great severity was an outburst of wind and blizzard conditions which swept eastward toward Cleveland on the afternoon of December 20, 1928, and was the occasion of the fatal crash of the air-mail plane, westbound from Cleveland with Pilot Leo McGinn, near Sandusky, Ohio, at 6 p. m. This squall reached phenomenal violence and was particularly dangerous because of the low temperatures and heavy snow. The onset of it at Cleveland brought a blinding snow storm during the last of the SSW. winds followed by decidedly colder weather and westerly gales; the temperature fell 9° and the pressure rose one-twentieth of an inch during an hour and visibility and ceiling were practically reduced to zeros during the passage of the storm. In the terrible commotion and violent currents and probably beset by ice-forming conditions in addition to the other difficulties, McGinn's plane was swept to the ground.

It was once remarked by Pilot J. D. Hill (of *Old Glory* fame) that to attack a line squall cloud was attended by tantalizing uncertainty as to the proper place to drive into it, for what appeared at one moment to be a brighter and less "dirty" zone in the clouds would suddenly transform itself into as black and ugly a cloud as was present and once firmly convinced that to go through was

the proper thing to do it might as well be penetrated at any point providing altitude and engine power were sufficient.

There is probably little in the account of the crossing of a number of line squalls by Kingsford-Smith over the Tasman Sea which has not been experienced at one time or another by the regular mail pilots of the lines near the Great Lakes. Accounts like this are rare however and we indulge in reproducing a part of the story here for that reason and also with the hope that accounts of phenomena met with in these line squalls may be inspired from the pens of those who come through them. The account is taken from the Quarterly Journal of the Royal Meteorological Society (British) January, 1929, number, as written by Director Kidson of the Dominion Meteorological Office. The flight lasted 14 hours and was from Australia to New Zealand, and for some unannounced reason was undertaken while a depression with line squalls was also crossing the Tasman sea. The plane left Australia at 5:25 p. m. September 10, 1928, heading east-southeastward:

At an altitude of 3,200 feet and a speed of 76 knots (88 miles per hour). The sky was partly cloudy and the visibility rather low. At 7:50 a very high cloud bank was seen ahead and at 7:55 p. m. lightning could be seen. At 8:45 the altitude was 5,400 and climbing. It was commencing to be very bumpy. At 10 p. m. the altitude was 8,000 feet and three separate thunderstorms were visible. The aviators were hoping to pass over the storm ahead of them. At 10:10 no rain had been experienced but the lightning flashes were becoming blinding. At 10:15 heavy rain was encountered, the altitude being 6,800 feet; the lightning flashes were very close. Bands of light encircled the propeller tips being about 9 to 12 inches wide around the center and narrower around the outside propellers. The light around the center propeller seemed to be bluish in color; occasionally the glow extended right to the hubs of the propellers. It would disappear after the lightning discharges and gradually recover. On two occasions the searchlight (30 volts 1,500 watts) was lit up by the current passing through it. The following hour was the worst experienced. Ice, apparently from supercooled raindrops formed on the windshield, the undercarriage, the engine bearer shafts, and the wing itself. It was subsequently estimated that at one stage the machine carried a half ton of ice. Hail was met with at times and the leading edges of the propellers, which consisted of a compressed cotton fabric were badly torn by it. It became very wet and cold in the cockpit. At 12:15 a. m. there was a calm interval with improved weather. At 12:20 another very severe rain and lightning storm was experienced, vertical velocities of 3,000 feet per minute being recorded. On one occasion there was a fall of 300 feet. The ice on the wings became thicker and in very severe bumps the plane was forced down from 7,000 to 2,000 feet. At 12:30 it was fine again and stars were seen. At 12:40 heavy rain and very severe bumps were again encountered. Ice remained on the machine and it was bitterly cold; the altitude was then 8,000 to 6,000 feet. At 1:45 the worst weather was past.

The account continues with the landing at Christchurch at 7:50 a. m. with improving weather and bumpy air and states that "when thunderstorms were first met and before the 500-foot wireless aerial could be wound in a discharge passed through it and damaged the 600 m. wireless set."

Those who fly largely in mountainous regions may find some consolation in the accepted and logical belief that the severest squalls occur over flat country near abundant sources of moisture, thus partly disposing of the dangers attendant upon blind flying at increased altitude, a maneuver which seems to have more to recommend it than the tactics of hedgehopping beneath it and taking the chances of being hurled to the ground in the violent vertical drafts of air met in that narrow margin of altitude. Ordinary planes may have little chance of hurdling above a line squall of the more boisterous type as the piled up vertical currents throw cumulus clouds with thunderstorm caps up into the cirrus levels at 20,000 feet, and ice and snow prevail. Pilots whose blind-flying is ragged

ought not to be encouraged to get more experience by taking the offensive with a line squall, but may learn something of its wiles by getting set down on a good field well in advance of the roll cloud of the squall and making sure of some shelter. Once passed the squall

will be followed by the weather of the other side which is not uniformly good but often marked by bumpy, rough, colder air, with numerous snow or rain squalls, scudding clouds and varying visibility which finally ease up when the colder change attains full possession of the territory.

EVAPORATION FROM RAIN GAGES

551.573 : 551.508.7

By HARRY G. CARTER

[Weather Bureau Office, Lincoln, Nebr.]

To determine the amount of water that would evaporate from a rain-gage measurements were made at Lincoln from May 1 to September 30, 1928. A standard 8-inch gage with receiving funnel and measuring tube in place was used in making the measurements. The water was placed in the measuring tube, the depth ranging from 5 to more than 10 inches (measuring 0.50 inch to more than 1 inch on a regular measuring stick). Readings were made at the time of the regular 7 a. m. and 7 p. m. observations.

The measurements were not in any way intended to determine the exact amount of evaporation from a free-water surface, but merely to give an indication of the amount of water that would evaporate from a rain gage during the interval between the ending of a rain and the measuring of the water.

The results of the measurements indicated that the daily evaporation averaged nearly 0.02 inch each 24 hours during May and approximately 0.01 inch each 24 hours during June, July, August, and September. Measurements also indicated that practically two-thirds of the evaporation occurred during the 12 hours between 7 p. m. and 7 a. m. Whether this was the actual condition or due to the crude method of measuring evaporation with a measuring stick with relatively large units, is questionable. But every month showed the greatest evaporation during the night.

Table 1 shows the average evaporation for the two 12-hour periods for each month during which measurements were made.

Since practically all the cooperative observers, at least in Nebraska, measure rainfall but once each day, usually late in the afternoon or early evening, it would

seem that there is a possibility that between 0.01 and 0.02 inch of water would evaporate from the gage before the rain was measured, particularly so when the rain fell a short time after observation and the water stood in the gage 15 to 20 hours before being measured.

TABLE 1.—*Evaporation from a rain gage at Lincoln, Nebr., from May to September, 1928*

	May	June	July	Aug.	Sept.
Average evaporation:	Inch	Inch	Inch	Inch	Inch
For the 12 hours, 7 a. m. to 7 p. m.-----	.005	.003	.002	.003	.004
For the 12 hours, 7 p. m. to 7 a. m.-----	.012	.006	.007	.006	.008
For the 24 hours, 7 a. m. to 7 a. m.-----	.017	.009	.009	.009	.012
Average percentage of total evaporation:	Per cent	Per cent	Per cent	Per cent	Per cent
For the 12 hours, 7 a. m. to 7 p. m.-----	29	33	22	33	33
For the 12 hours, 7 p. m. to 7 a. m.-----	71	67	78	67	67

During the months when precipitation is practically all in the form of rain, say from the 1st of April to the last of September, there are, on an average, between 45 and 55 rainy days in Nebraska. Since approximately two-thirds of these rains fall during the night hours and the water is not measured until late the next afternoon, it would seem that there would be a loss of water by evaporation amounting to between 0.30 and 0.60 inch during the six months.

From the above it would appear that cooperative observers should be encouraged to measure rainfall after each fall, or if this is impracticable, as it would be in many cases, to make measurements both morning and evening, keeping in mind that the amount to be entered on the daily record should be the amount that fell during the 24 hours ending at the hour of observation

COAST FOGS AND RADIOBEACONS

551.575

By WILLIS E. HURD

[Weather Bureau, Washington]

Recently in connection with a study of fog at sea, made at the central office of the Weather Bureau, there arose an informal discussion with the Lighthouse Service as to whether, fog being present at a given lighthouse, say on the southern New England coast, one might reasonably determine upon the probabilities of simultaneous fog occurrence at another lighthouse a considerable number of miles distant.

While there are many instances of fog obscuring in an unbroken sheet a long stretch of sea off the coast, more frequently such surface condensation is of a spotted character, depending upon the local contour of, and amount of sea envelopment by, the adjacent land; neighboring conditions of atmospheric pressure; the direction and steadiness, or variability, and force of the wind; the differences in temperature between adjacent water surfaces, or between that surface and the overlying air, etc. In almost any case there is great difficulty attending the successful forecasting of sea fogs.

Apart from the purely meteorological probabilities involved, it is interesting to note that various light stations incidental to their position finding signals by radiobeacon, are giving special information as to fog and thick weather whenever it exists in their vicinity.

In the Lighthouse Service Bulletin of the Department of Commerce for March 1, 1929, appears the following item bearing upon this subject:

FOG INFORMATION BROADCAST FOR SHIPPING

In addition to their primary purpose of providing signals on which ships can take accurate bearings by radio, the radiobeacon system incidentally broadcasts valuable information as to fog and low-visibility conditions along the coast.

These signals are operated during fog or low visibility and are silent in clear weather, excepting for certain regular time schedule operating periods, which are published for each station. Therefore, a navigator has a